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MICROSEISMIC MONITORING AT NEW QUIRKE MINE

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MICROSEISMIC MONITORING AT NEW QUIRKE MINE

by

P. MacDonald*

ABSTRACT

In March 1982, a series of rockbursts caused a severe deterioration in the structural stability of an area of New Quirke, which had been mined out two years previously, where stress related features were already in evidence. Following preliminary studies, it was concluded that multichannel detection of microseismic activity provided a means of continuously monitoring the expansion of the affected area, particularly in the direction of existing and proposed working areas. A system was installed, comprising an underground geophone array connected to a surface processing unit. By the use of a dedicated microcomputer, some degree of automation has been achieved in identification of microseismic events and plotting occurrences on mine plans. Long-term plotting and contouring aids in the identification of highly stressed areas and defining any trends in the development of rockburst zones.

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MINING BACKGROUND

New Quirke Mine (see Fig. 1) was developed on the North limb of a broad syncline in the Pre Cambrian Matinenda Formation, at a depth of 250 to 750 m. The strata adjoining the uranium-bearing conglomerate reefs are quartzites, argillites and basement greenstones, generally dipping 20° south. The rock is classified as strong, brittle and elastic. In the eastern portion of the mine, at a depth of 600 m, a localized reduction in dip presented an opportunity to change the mining method from conventional room and pillar to mechanized trackless stopes (see Fig. 2).

ROCKBURST ACTIVITY

Stress-related rock failure was noted as early as June 1980, fifteen months after extraction was completed in the location. Progressive degradation was observed, including fractured pillars, pillar spalling and floor heave, in pillars immediately up-dip of the trackless area, i.e., the trackless crown pillars and the sill pillars of 700 level stopes, between 776 and 782. In the succeeding eighteen months, the area of disturbance radiated outward to incorporate the rib and centre pillars of stopes 775-781 (up-dip) and the crown pillars of down-dip stopes 875-882. Mine personnel heard strata noise during the first quarter of 1982, culminating, on March 10th, in a small rockburst which probably occurred on the 700 level.

A series of bursts ensued, being particularly frequent on March 12. Figure 3 is a summary of the expansion of the disturbed area over the period June 1980 to October 1982. The rapid increase in areal extent in the spring of 1982 is evident. The concurrent development of three further zones of pillar deterioration is also illustrated in Fig. 3.

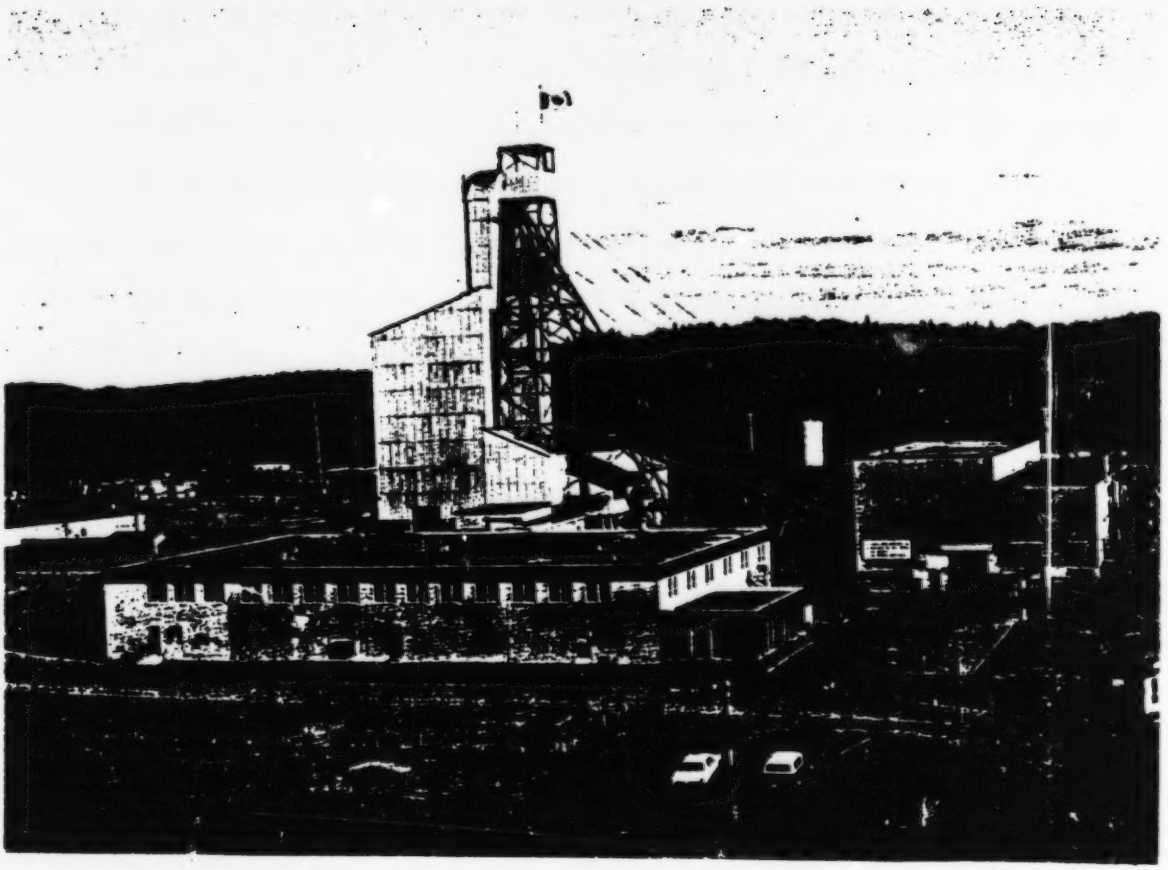


Fig. 1 - New Quirke mine.

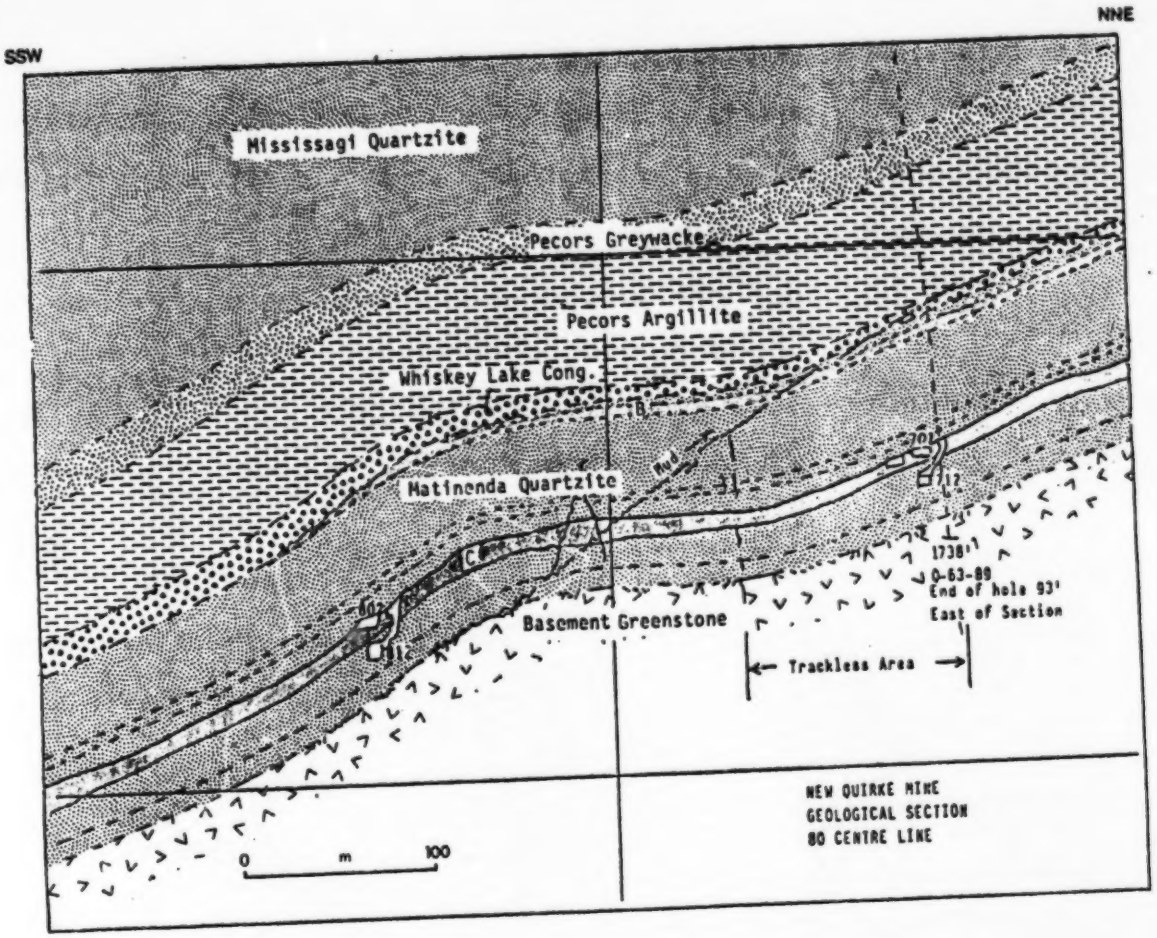


Fig. 2 - Geological section, New Quirke mine, east end.

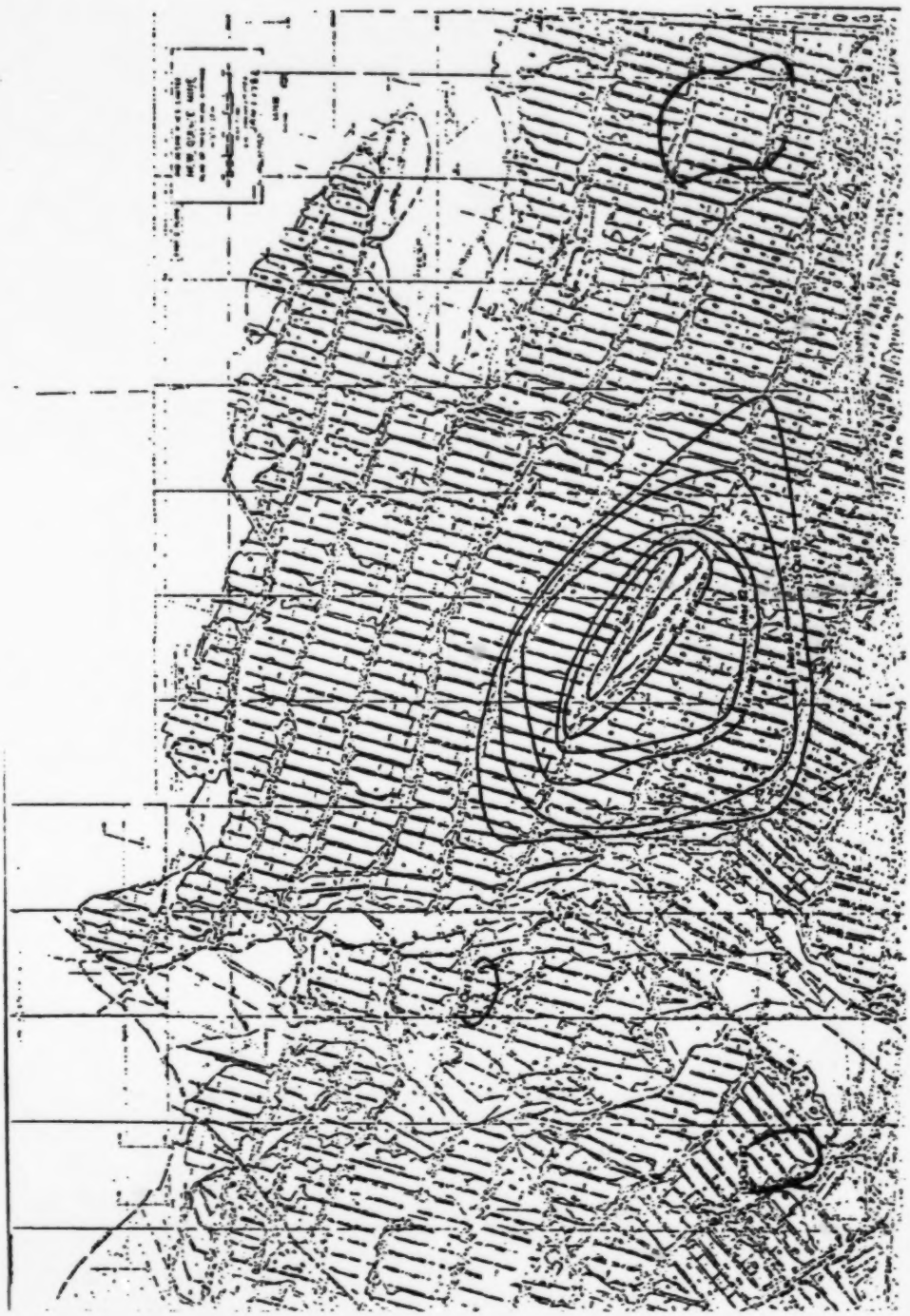


Fig. 3 - Extent of disturbed area, Jan. 1980 - Oct. 1982.

INITIAL INSTRUMENTATION

On Friday, March 12, 1982, a Teledyne Geotech Short Period (SP) seismograph, on loan from Denison Mines Ltd., was installed at the closest practicable location to the affected area, in the 800 East electrical substation. The instrument employs a 1 Hz seismometer, the signal from which is conditioned and recorded, with a time signal, on a drum recorder. The seismometer was mounted on a horizontal plate welded to a rockbolt, the remaining components being contained in a cabinet. Daily replacement of the heat-sensitive paper charts and some maintenance demanded frequent underground visits to the instrument.

Microseismic events were arbitrarily classified into three divisions as detected by the seismometer (see Fig. 4):

(i) Major - generally felt on surface;

(ii) Intermediate - other significant events;

(iii) Minor - mainly small and localized, possibly some distant intermediate events.

It should be noted that a single detector cannot be used to differentiate between absolute magnitude and location of events. Therefore, small events close to the seismometer appear similar on the chart recorder to large distant events.

An improvement was effected to the maintenance of the monitoring system by installation, on the 800 level, of a Geomonitor, manufactured by Slope Indicator Co. (see Appendix). This wide band monitor possesses a frequency response of 2 to 18000 Hz using a pressure sensitive accelerometer. Signal transmission to the surface was achieved through coaxial cable from the low impedance headphone output of this instrument. This signal was then recorded on the drum recorder of the seismograph and on an instrumentation tape recorder

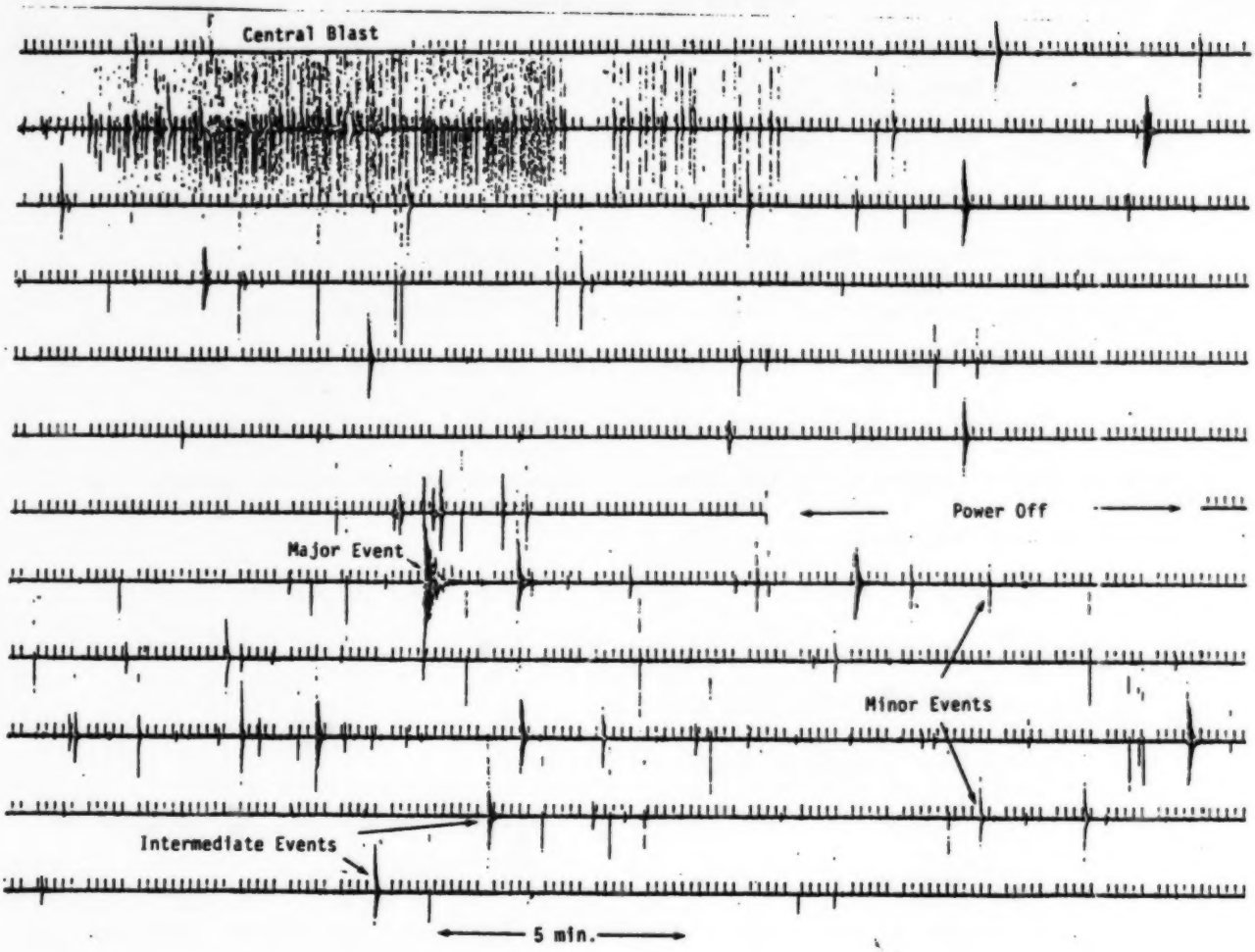


Fig. 4 - Part of helical record from SP seismograph.

for future analysis.

Histograms of microseismic activity were calculated, as detected originally by the seismometer and subsequently by the Geomonitor accelerometer, and are reproduced in Fig. 5. Certain events were observed on Canadian Seismograph Network records, particularly in March.

The instrumentation installed at New Quirke provided mine management with a continuous record of microseismic activity in and around the disturbed area. However, if production was to be resumed to the south of the rockburst zone, an accurate assessment of the stability of the area was required. While convergence meters were installed and patrols by mine personnel implemented, these provided only periodic information on disturbances in the eastern part of the mine. For safety purposes, it was preferable to maintain continuous monitoring of microseismic events and rapidly locate event sites. A multi-channel microseismic monitoring system was specified, capable of fulfilling the following objectives:

(i) to locate the source and calculate the energy of each seismic or microseismic event;

(ii) to discover any relationship between strata noise, pillar damage and mining activities;

(iii) to recognise any trends in microseismic activity preceding rockbursts;

(iv) the rapid transmission of relevant information to mine management;

(v) by these, and any other means, assess the stability of pillars and hanging wall.

Based on these criteria the purchase of an Electro Lab MP-250 monitoring system was approved for installation at New Quirke mine.

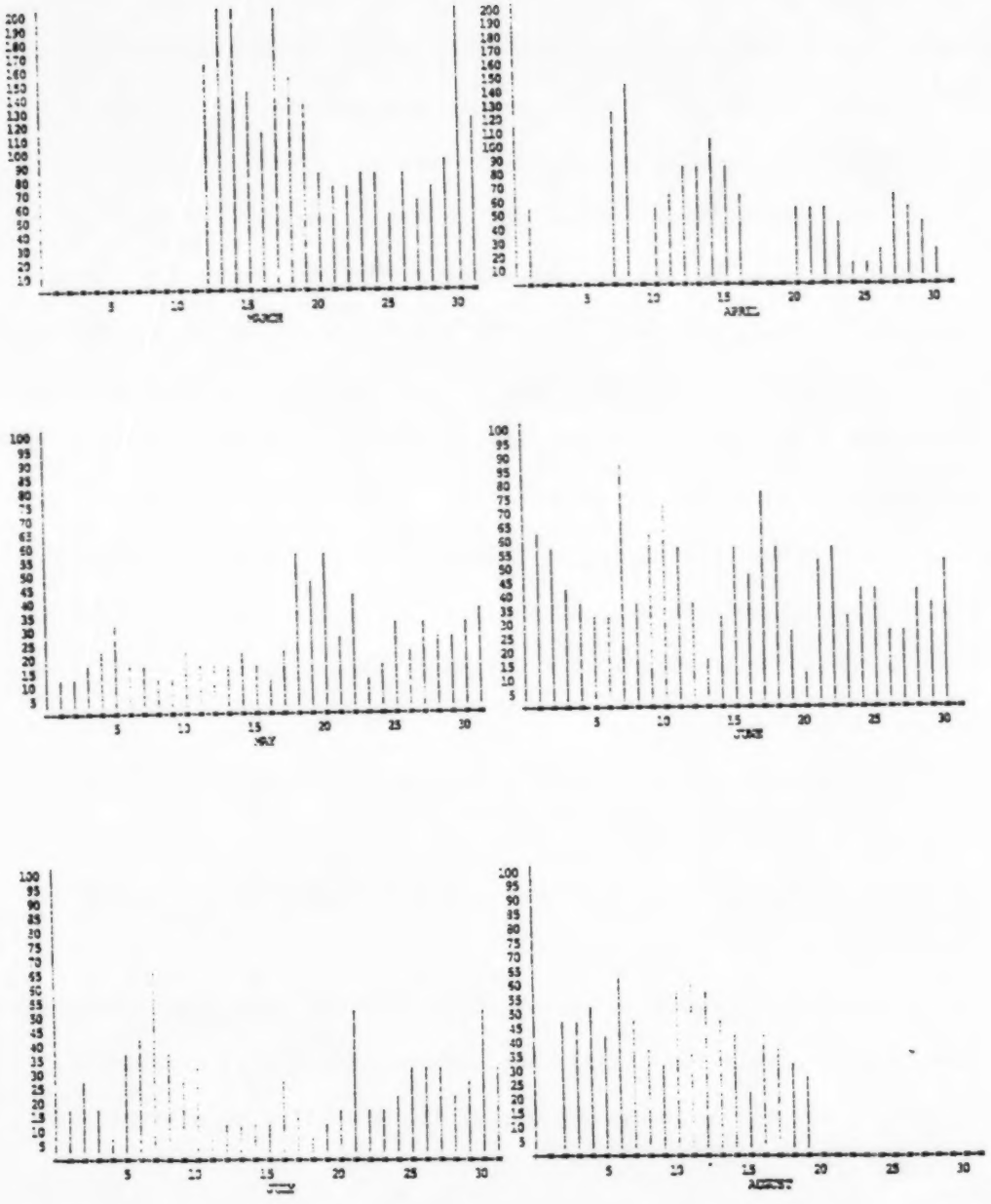


Fig. 5 - Histograms of microseismic activity, March to August, 1982. (Note change of scales).

THE MP-250 MICROSEISMIC SYSTEM

A block diagram of the 16 channel system specified for this application is presented in Fig. 6.

Geophone signals are amplified at source by a preamplifier with a low-impedance output. The analog voltages in the 16 channels are conducted through screened cables to signal conditioning and filter interfaces at the surface processing unit.

Controlled by a program in non-volatile Read-only-memory (ROM), the microprocessor 250 MP-1 sweeps the input signals. When any signal voltage exceeds a preset threshold, a time 'window' is opened and event processing is initiated. The time window duration is variable between 100 μsec and 999 msec. If a minimum of four more channels are triggered during this period, an 'event' is deemed to have occurred, the time of which is recorded from the 250 MP-4 event timer at the point at which the time window was opened. At the end of each event, the time window is reset and identification and arrival time data for the 5 to 16 channels is stored for use by the 250 MP-2 processor in the source location algorithm. See next section for a brief description of this stage. The 250 MP-1 is capable of storing the criteria for up to 100 events, should they occur in rapid succession. Input/output is via a RS 232 serial interface, usually to a printer-terminal, or in the case of Quirke II to a microcomputer.

Sixteen detectors were installed to form an array encompassing an area approximately 750 m x 600 m (2500 ft x 2000 ft) as shown in Fig. 7. One vertical uphole, three vertical downholes and twelve horizontal holes 5.4 cm diameter x 1.9 m (2-1/8 in. diameter x 6 ft) long, were drilled in drifts and strike pillars. Hole orientation was specified at ± 5° of true, with horizontal holes being drilled slightly upward for self-draining of water. Resin discs, 4.5 cm diameter x 3.8 cm thick (1-3/4 in. x 1 1/2 in.), were drilled

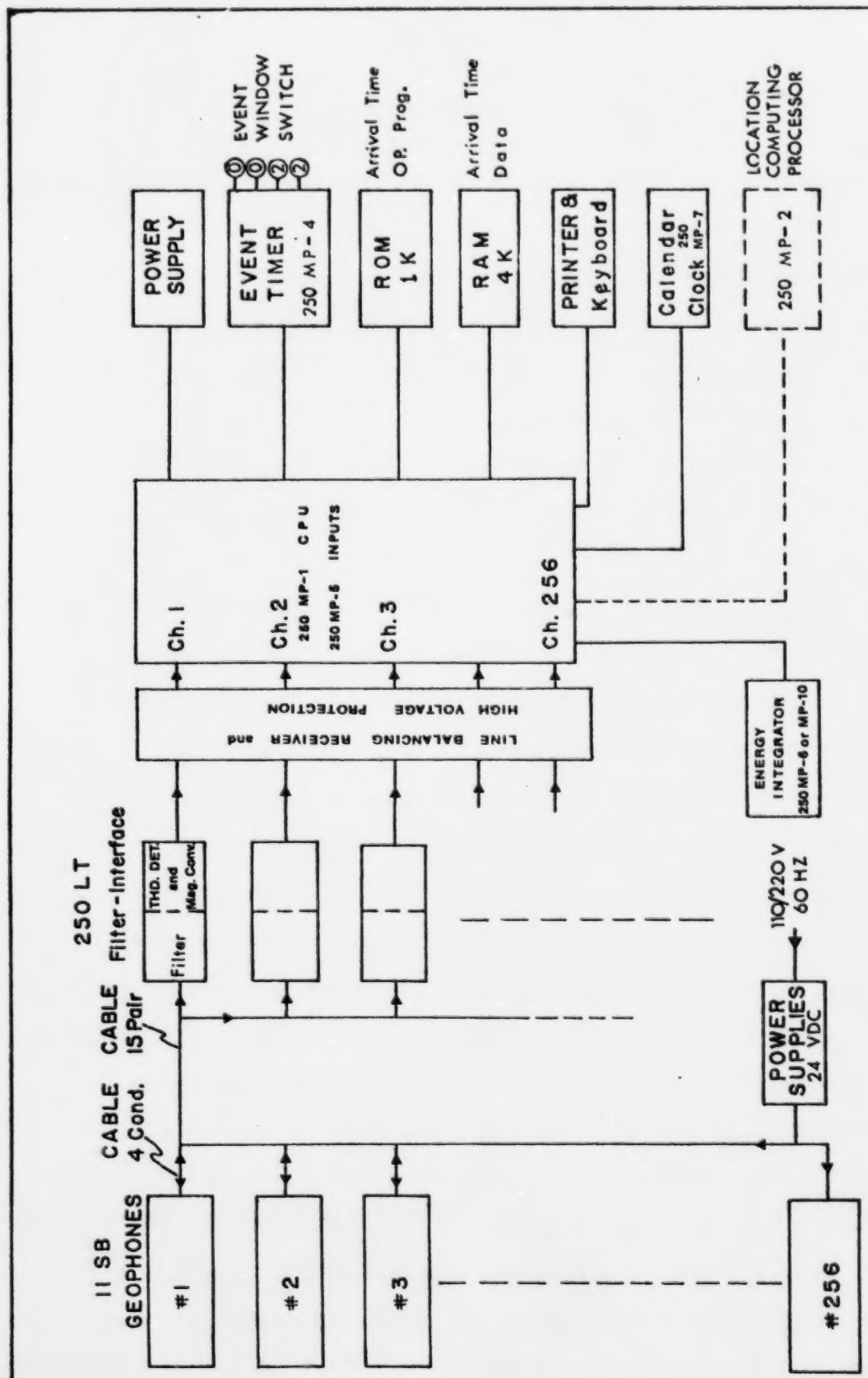


Fig. 6 - BLOCK DIAGRAM - 250 MP SYSTEM

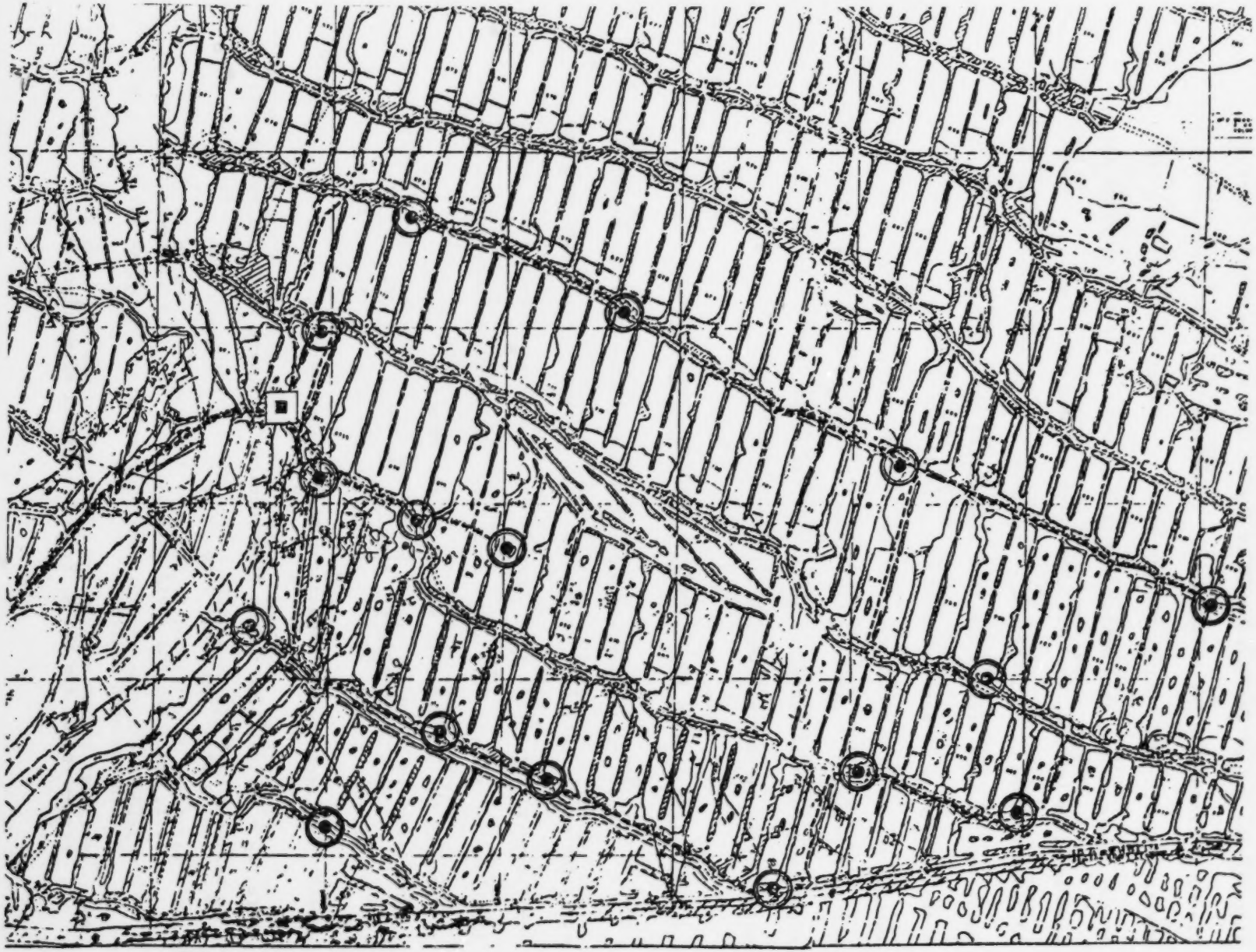


Fig. 7 - Location of Geophones and Junction box, New Quirke mine.

tapped and countersunk, into which the geophones were screwed. Cementing the discs to the end of the holes enabled the detectors to be firmly fixed in place, yet removable for maintenance. To overcome water problems, downholes were cased with UPVC tubing, plastic steel being used as adhesive at the bottom of the hole. This method provides protection for the geophone and a good detector to rock coupling. The geophones are connected by a total of 10,000 m (30,000 ft) of screened 4-way cable to a central junction box and power supply. The signals are then transmitted through 2,000 m (6,000 ft) of overall screened 25-pair cable to the processor on surface. Care was taker to install the cable near to the roof wherever possible, away from spalling pillars and in a sequence to minimize the number of cable connections required. The copper screens were connected throughout the array, and earthed at one point only, at the surface system cabinet.

DATA PROCESSING AND SOFTWARE DEVELOPMENT

The 250 MP-2 processor module receives channel numbers and arrival times for each event, from which data, with geophone co-ordinates originally input through the serial interface, linear equations are solved and source locations and seismic velocities computed. The equations were originally utilized by the U.S.B.M. (1) and are of the form (2):

$$2\left[\frac{a_1-a_2}{t_2} - \frac{a_1-a_n}{t_n}\right]X + 2\left[\frac{b_1-b_2}{t_2} - \frac{b_1-b_n}{t_n}\right]Y + 2\left[\frac{c_1-c_2}{t_2} - \frac{c_1-c_n}{t_n}\right]Z$$

$$+(t_n - t_2)V^2 = \left[\frac{r_1^2-r_2^2}{t_2} - \frac{r_1^2-r_n^2}{t_n}\right] \quad \text{for } n = 3, 4, 5, 6.$$

where, t_n = arrival time n, the time required for event spherical wave front to pass from phone 1 to phone n. t_1 is always zero.

X, Y, and Z are the coordinate axes, in this case the coordinates of the unknown source.

a_n, b_n and c_n are the X, Y, Z coordinates of geophone n.

V = P wave velocity, and is assumed constant for all directions. This may not be true in practice, but only minor location errors are introduced by this assumption

$r_n^2 = a_n^2 - b_n^2 - c_n^2$.

A maximum of four solutions are calculated, if sufficient geophones have been activated. Time differences between the first six arrivals are used to calculate the source location and seismic velocity. This is repeated for arrivals two to seven and three to eight, the final possible location being evaluated using the fourth to eighth arrival times and the velocity stored in the processor memory. This assumed velocity is also used to calculate the event source in the case where only five channels are triggered within the time window. The module possesses a battery in order to retain geophone coordinates and seismic velocity data during temporary mains power supply failures.

Accurate microseismic source location by this method is based on the principle of energy propagation, in homogeneous media, of a spherical wavefront from a source of small dimensions. Time of arrival of the vibration is then proportional to the distance from the source to the detector. In the mine situation, the radiated sphere is distorted by variations in seismic velocity, caused for instance, by heterogeneous strata and excavations. The longitudinal wave velocity has therefore to be determined on site. Yu (3) measured sonic velocity in an Elliot Lake mine and derived an average value of 5500 m/sec (18,000 ft/sec). In addition, calibration tests were conducted using explosive charges. Accurate determinations of the known locations resulted only from the firing of single shotholes. Stope blasts release energy from a series of simultaneous sources across the width of a stope, generally 20 m (65 ft). This, with the firing of charges on delays, creates interference and complex vibrations from which the monitoring system produces anomalous locations. The

results from the appropriate tests indicated a seismic velocity of 5950 m/sec (19500 ft/sec) was more suitable for New Quirke mine.

In most installations of the 250-MP system, final output is to a printer, differentiation between microseismic and blasting events being a tedious manual task. A TRS-80 Model 16 microcomputer was therefore connected to the monitoring system to provide data processing beyond that incorporated in the monitoring system.

A menu-driven suite of programs was written, initially in interpreted BASIC, in two categories:

a) Interface programming to receive, process and store parameters;

b) Graphics software to enable automatic plotting of event locations on mine plans.

Figure 8 summarizes the operation of these programs.

EVENT STORAGE

a) MONITOR. Information is transmitted from the monitoring system in the format illustrated in Fig. 9, and is stored on hard disc by program 'MONITOR'. This program is designed to run continuously, creating files of event data on a daily basis.

b) EVENT. Analysis of the output files is conducted by 'EVENT', employing arbitrary criteria to reject spurious events on the basis of the velocity, as calculated by the algorithm, elevation or location within the mine.

A subroutine within the program computes the approximate stope number, in the eastern area of the mine, in which the event occurred. This is derived from the fact that the geometry of the mine layout in this region is sufficiently linear to permit strike and dip pillars to be approximated to straight lines. The formulae of the lines representing the pillars are:

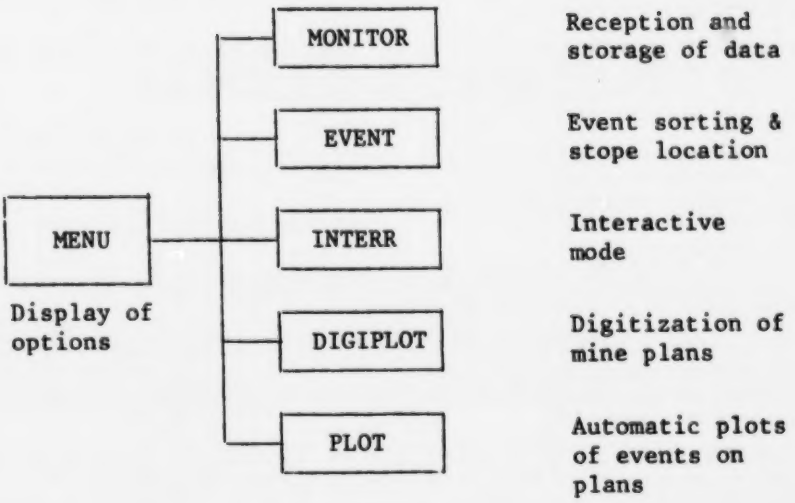


Fig. 8 - Operation of program 'MENU'.

```
Dy 0340 Hr 19 M 52 S 04.98
Ch 09 00000 Ch 14 00075 Ch 15 00105 Ch 00 00975 Ch 03 01110 Ch 10 01220
Ch 05 01675 Ch 07 01690 Ch 01 02380
N En 0068
X=+062093 Y=+005226 Z=+013769 V=-000001
X=+062082 Y=+005088 Z=+014029 V=-000001
X=+064100 Y=+009041 Z=+002639 V=+157472
X=+063648 Y=+008307 Z=+005025

Dy 0340 Hr 19 M 52 S 45.87
Ch 07 00000 Ch 08 00850 Ch 06 01340 Ch 11 02705 Ch 12 02940 Ch 04 03655
Ch 13 03740 Ch 15 04235 Ch 01 04875 Ch 00 05140 Ch 14 06890 Ch 09 07230
Ch 05 09000 Ch 10 09010 Ch 03 11275
N En 2000
X=+061754 Y=+006425 Z=+009487 V=+012334
X=+061614 Y=+006092 Z=+010426 V=+023932
X=+061936 Y=+007184 Z=+006523 V=+051906
X=+061845 Y=+007177 Z=+006336

Dy 0340 Hr 19 M 52 S 46.41
Ch 08 00000 Ch 07 00460 Ch 06 00595 Ch 12 03115 Ch 03 03430 Ch 10 03620
Ch 00 06085 Ch 01 07125 Ch 14 11750 Ch 13 14640
N En 0100
X=+057366 Y=+011689 Z=-010841 V=-000001
X=+064233 Y=+009906 Z=+000979 V=-000000
X=+065352 Y=+012277 Z=-005675 V=-000000
X=+075160 Y=+032674 Z=-063205

Dy 0340 Hr 19 M 52 S 46.63
Ch 07 00000 Ch 08 02445 Ch 14 04105 Ch 12 04975 Ch 10 06350 Ch 06 06675
Ch 13 10490 Ch 03 11795 Ch 01 12785
N En 0066
X=+062278 Y=+005625 Z=+011798 V=+015571
X=+062319 Y=+005750 Z=+012068 V=-0000
X=+063215 Y=+007496 Z=+007191 V=+014407
X=+065432 Y=+011746 Z=-006774

Dy 0340 Hr 19 M 52 S 56.24
Ch 07 00000 Ch 06 12830 Ch 08 14110 Ch 11 16330 Ch 04 17075 Ch 13 18665
N En 0051
X=+061574 Y=+006130 Z=+010634 V=+005178
X=+061758 Y=+006612 Z=+008988

Dy 0340 Hr 19 M 53 S 06.36
Ch 07 00000 Ch 06 17750 Ch 08 17870 Ch 11 19565 Ch 04 19970
N En 0078
X=+064290 Y=+020709 Z=-032079
```

Fig. 9 - Output format from the 250-MP

sills: $y = -0.5x + C$

dip pillars: $y = 3.0x + C$

where, C is the intercept at grid 60500E for each pillar line. Determination of C in each equation, from the x,y coordinates, results in the stope number for the event.

The result of this analysis is a list comprising three types of events:

(i) Natural microseismic events;

(ii) Accurately located blasts;

(iii) Microseismic activity induced by blasts.

A daily summary can then be printed as shown in Fig. 10, including event time, x,y coordinates and approximate stope number. A file is also created of events located in an adjoining mine. While the accuracy is diminished beyond the boundary of the array, the management of the second mine receives an indication of the stability of the rockburst zone on the property.

c) INTERR. Geophone coordinates and an assumed seismic velocity are required to enable the monitoring system to perform source location. The system can also be interrogated to obtain certain status reports and data. A fully interactive mode is available for this purpose, using program 'INTERR' as a means of exchanging information through the RS232 serial interface.

Since the 250 MP responds to computer keyboard commands only while using 'INTERR', this program is password protected to maintain security of the overall monitoring system. Only a trained operator should therefore, use the program and be in possession of the password, see Table 1.

Exiting 'INTERR' and returning, via 'MENU', to 'MONITOR' continues monitoring and data storage on microcomputer hard discs.

PRINT-OUT OF EVENT FILE S2EEV340

Day	Time	Location				En	AbsE	Stope
340	19 50 54.69	61750	6439	9453	12868	0351	1869	875
340	19 52 45.87	61754	6425	9487	12334	2000	10578	875
340	19 52 46.63	62278	5625	11798	15571	0066	735	981
340	19 52 56.24	61758	6612	8988	19500	0051	329	875
340	19 53 06.70	61020	5690	9367	19500	0222	1206	1172
340	19 53 09.72	60505	5434	8746	16699	0286	3069	1169
340	19 55 10.82	62126	5944	11252	19500	1328	11353	979
340	19 55 21.67	61510	5873	11359	17636	0588	2083	1075
340	19 55 35.58	61945	6725	8275	19500	0281	2419	876
340	19 55 40.89	61651	6162	10291	19500	0040	141	975
340	19 55 41.10	61504	5704	10441	19500	0028	139	1075
340	19 55 48.57	61647	6241	9660	25240	0069	247	975
340	19 55 48.77	61655	6269	9647	19500	0047	175	975
340	19 56 18.53	61687	5666	12298	19500	0276	1728	1076

Fig. 10 - Daily listing of events from microcomputer.

Table 1 - Summary of Commands

<S>	turns processor off-line, i.e., no events processed, then:
<P><F>	displays on/off status of geophones and current stored velocity value.
<P><D><n><n>	displays stored coordinates of geophone nn.
<P><T>	displays contents of 64 registers which store the number of times individual channels are triggered.
<P><E><n><n>	prompts operator to enter (x,y) coordinates for geophone nn.
<P><V>	precedes value of velocity to be stored for use in location computations.
<P><N><n><n>	enables geophone channel nn.
<P><X><n><n>	disables geophone channel nn.
<P><Z>	zeroes all registers storing numbers of triggering occurrences for each channel.
<C>	Processor is turned 'on-line' to process events and responds with 'Rdy'

EVENT DISPLAY

a) 'DIGIPLOT'. This program is called when mine plans are digitized for presentation of event locations. Initially, 300 m (1000 ft) square segments of the eastern portion of New Quirke were digitized and stored in pictorial form. 'DIGIPLOT' is also used to edit and update existing plan files. Future incorporation of scaling, for magnification or reduction of the segments will add flexibility to the display programs.

b) 'PLOT' combines the results of EVENT and DIGIPLOT to display on the VDU the appropriate events on selected plan segments. Facilities exist within the program to use different symbols for events of various magnitudes and to plot microseismic activity over extended periods to identify trends or zones of stress concentration. Subsequently, a hard copy of the results can be produced by a 'screen dump' to a dot matrix printer, as presented in Fig. 11.

RESULTS

The results from three months' operation of the ElectroLab MP-250 illustrate the progressive automation of event identification by the microcomputer. On installation, final output was in paper form from a printer/terminal, identification of microseismic events being a very time-consuming operation, but providing invaluable interpretative experience.

Interfacing to the microcomputer was achieved after some delay due to the non-standard connector on the MP-250 and information was then stored on hard disc. Following a period of simply printing out the data in the same form as transmitted, the programs described above were developed and implemented.

A major contribution was made by the automatic rejection of anomalous events based on arbitrary criteria. Although a certain number of blasts are

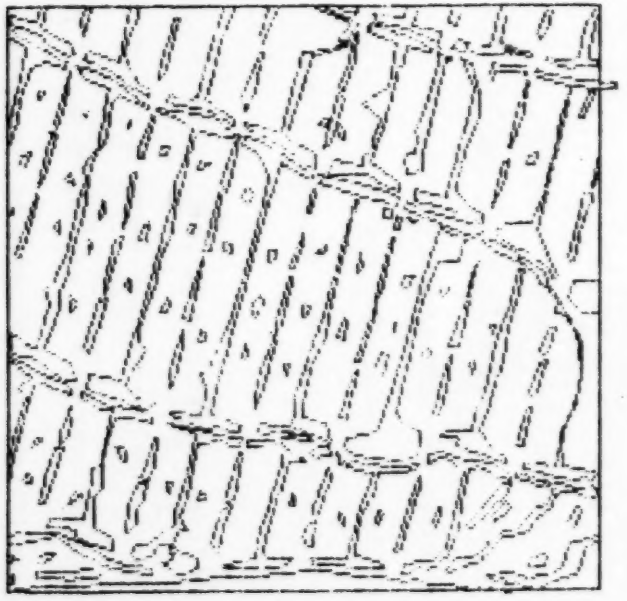


Fig. 11 - Example of mine plan segment produced by microcomputer.

included in the output file, the approximate stope location enables rapid identification of events induced by blasting or occurring during blasting periods. These occurrences tended to be concealed in the mass of data produced at the times of central blast.

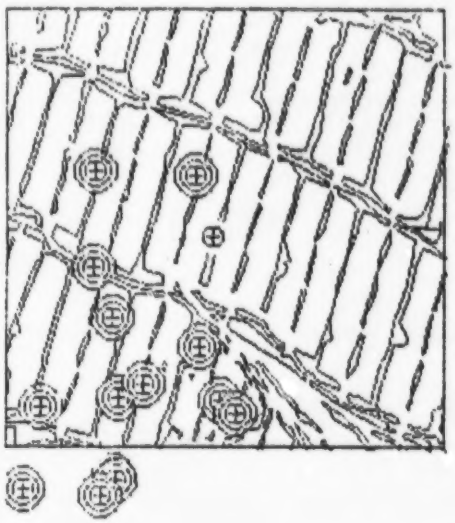
Computerized plotting of events enabled a visual representation to be made in ten minutes of all microseismic activity occurring within the preceding 24 hours. Figure 12 illustrates microseismic events that took place in one day, and Fig. 13 for a period of one week. The file of events can also be used for long term plotting, e.g., for three months as shown in Fig. 14. Contouring aids in identification of highly stressed zones.

Identification by mine personnel, of pillar and rock burst sites underground indicates that the monitoring system source location possesses an accuracy of ± 15 m within the area of the geophone array and ± 50 m up to 300 m outside the array. Thus it is evident that a total area of 1200 x 600 m is being monitored with reasonable accuracy.

CONCLUSIONS

The SP seismic system and the Geomonitor proved the feasibility of monitoring strata noise at New Quirke mine. However, identification of individual rock failure sites was required for purposes of safety and information. This facility is not, however, provided by single channel systems and furthermore the large area under investigation could only be reliably monitored by several detectors.

Immediately upon installation, the 16 channel ElectroLab MP-250 system produced accurate locations for microseismic events. A reasonable degree of accuracy (± 50 m) is maintained over an area of 700,000 m^2. A previously unrecognized zone of pillar failure was indicated by the system, being proven



EVENTS FOR DEC 6/7

NO. OF EVENTS = 15

TOTAL ENERGY = 53712

STOPE	775	ENERGY =	1993
STOPE	774	ENERGY =	1568
STOPE	775	ENERGY =	244
STOPE	876	ENERGY =	1421
STOPE	875	ENERGY =	1869
STOPE	875	ENERGY =	10578
STOPE	875	ENERGY =	1329
STOPE	876	ENERGY =	2419
STOPE	773	ENERGY =	9514
STOPE	875	ENERGY =	6422
STOPE	874	ENERGY =	8144
STOPE	974	ENERGY =	2897
STOPE	975	ENERGY =	1919
STOPE	877	ENERGY =	1653
STOPE	874	ENERGY =	1740

Fig. 12 - Events in one segment for Dec. 6/7, 1982.

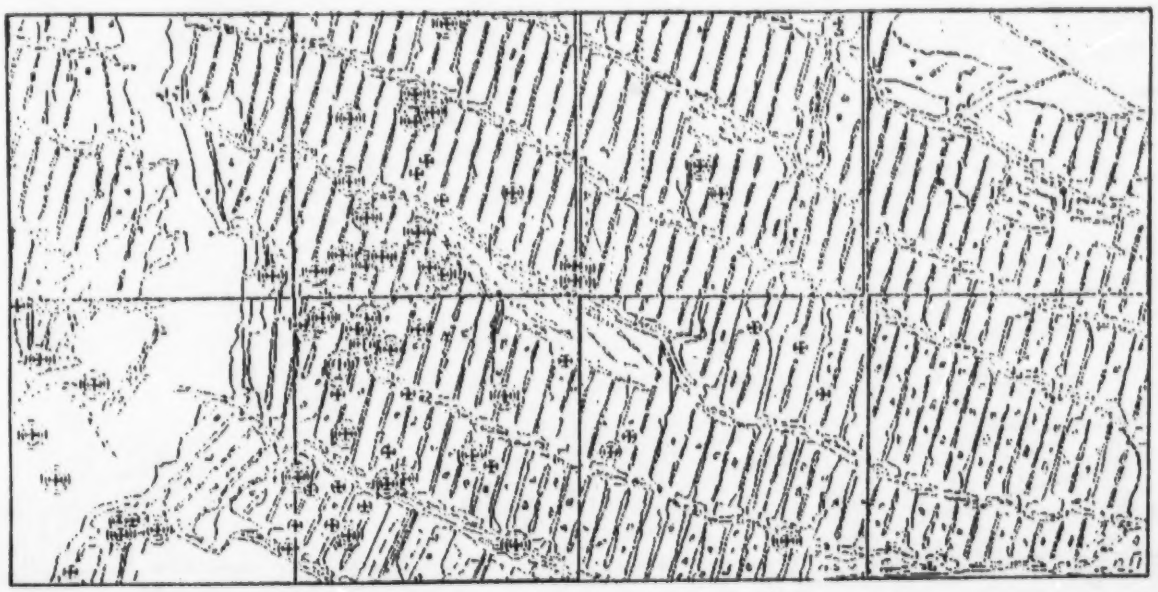


Fig. 13 - Summary of events for the week ending Dec. 12, 1982.

Fig. 14 - Frequency contours for Aug. to Oct. 1982. (Contour interval - 2 events per 30 m square.)

by subsequent inspection of the area by mine personnel. A total of four individual rockburst zones in two mines are therefore situated within the overall monitoring area of the system.

Computerized microseismic event identification, plotting and stope location have dramatically decreased the analysis time compared with the initial manual method. Some degree of manual interpretation remains, but the information is presented in a form that can be digested rapidly and acted upon accordingly. The presence of mining crews adjacent to the southern part of the major disturbed area requires that the information from the monitoring system be quickly available for safety purposes.

From plots of microseismic activity over weekly or monthly periods, identification can be made of any trends or progression of rockburst area boundaries, and are therefore an aid to mine management in planning operations in these sectors of the working areas.

ACKNOWLEDGEMENTS

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The Slope Indicator MS-3 GEO-MONITOR is a highly sensitive detector of sub-audible acoustic emission from in-situ rock and soil stress. The information acquired by the MS-3 can be used to evaluate the relative activity and potential failure of monitored materials and areas. The extreme sensitivity of the MS-3 permits application to: Stability studies of excavation walls, tunnels, mines, glacial areas, and slides; location of leakage paths in dams, reservoirs and pipe lines; warning of overstress to structural components; and activity studies of volcanic areas and fault zones.

The MS-3 GEO-MONITOR is a portable, battery operated system complete with transducer, cable, earphones, amplifier, filter, event counter, rate counter, analog output, and battery charger.

Two sizes of transducers are available: A 1.875-inch (48 mm) diameter unit for NX or larger boreholes, and a .875 (22 mm) diameter for small, jackhammer size holes. Both sizes can be interchanged.

Front: Model 53306 MS-Transducer.
Back: Model 53305 MS-Transducer.

Transducer output is high level, low impedance, and capable of driving cable lengths of more than 1,000 feet (300 m). The standard aluminum transducer housing is sealed to withstand water pressures up to 200 psi (1400 kPa). A stainless steel housing is available for permanent burial, and for use in corrosive conditions and water pressures up to 500 psi (3500 kPa).

An integral event counter records each occurrence of an event above the adjustable threshold level. The rate counter conveniently measures the events per minute for either a one minute or ten minute sample period.

Available accessories include: Tape recorders, storage oscilloscopes, and oscillographs.

Since this is a scientific instrument, measurements should be taken, recorded and interpreted by qualified personnel. SINCO is not responsible for errors or omissions of the personnel used.

SPECIFICATIONS:

Sensitivity:	10 db signal/noise ratio for 1 μ bar pressure input signal.
Transducer Output:	-40 dbv/μ bar (.01v/μ bar)
Overall Voltage Gain:	126 db (2×10^6)
Frequency Response:	2Hz to 17 kHz ($\pm$ 3db)
Filters:	High Cut: -3 db point selectable at 10 kHz, 1 kHz, or 100 Hz for 40 db per decade roll-off. Low Cut: -3 db point selectable at 100 Hz, 1 kHz, or 10 kHz for 40 db per decade roll-off.
External Analog Output:	5 volt peak to peak maximum into 10 k ohm or greater impedance.
Event Counter:	1×10^8 counts, resettable.
Rate Counter	Maximum 1000 counts/minute.
Power Requirements:	115/230 VAC 50/60 Hz for charger. External 11-14.7 VDC at 150 mA avg. 24 hours of continuous operation with internal batteries.
Instrument Case Size:	Height 10 in., Width 7 in., Length 11 in. (250 mm x 180 mm x 280 mm) Weight 14 lbs. (6.4 kg.)

TRANSDUCERS:

Model	Outside Diameter	Length	Weight
53305	1.875 in (48 mm)	3.25 in (83mm)	0.8 lbs. (0.4 kg)
53306	.875 in (22 mm)	6.62 in (168 mm)	0.4 lbs. (0.2 kg)